IN THE SPECIFICATION:

Please substitute the paragraphs below for the paragraphs previously presented. Changes to the paragraphs are shown with additions underlined and deletions in ~~strikethrough~~ text.

Please replace the paragraph starting on page 1, line 10, with the following paragraph:

This application is a continuation of application serial no. 08/965,720, filed November 7, 1997, now U.S. Patent No. 6,166,723. Application serial no 08/965,720 is a continuation-in-part of co-pending parent patent applications serial no. 08/560,091, filed November 17, 1995, on behalf of Rosenberg et al., entitled "Method and Apparatus for Providing Low Cost Force Feedback and Mechanical I/O for Computer Systems", now U.S. Patent No. 5,805,140, serial no. 08/756,745, now U.S. Patent No. 5,825,308, filed November 26, 1996, on behalf of Rosenberg et al., entitled, "Force Feedback Interface having Isotonic and Isometric Functionality," and serial no. 08/881,691, now U.S. Patent No. 6,100,874, filed June 24, 1997, on behalf of Schena et al., entitled, "Force Feedback Mouse Interface", all assigned to the assignee of this present application, and all of which are incorporated by reference herein.

Please replace the paragraph starting on page 10, line 35, with the following paragraph:

There are two primary "control paradigms" of operation for mouse system 10: position control and rate control. Position control is the more typical control paradigm for mouse and similar controllers, and refers to a mapping of mouse 12 in which displacement of the mouse in physical space directly dictates displacement of a graphical object. The mapping can have an arbitrary scale factor or even be non-linear, but the fundamental relation between mouse displacements and graphical object displacements should be present. Under a position control mapping, the computer object does not move unless the user object is in motion. Position control is not a popular mapping for traditional computer games, but is popular for other applications such as graphical user interfaces (GUI's) or medical procedure simulations. Position control force feedback roughly corresponds to forces which would be perceived directly by the user, i.e., they are "user-centric" forces. Also, "ballistics" or other non-linear adjustments to cursor position can be used, in which, for example, small motions of the mouse have a different scaling factor for cursor movement than large motions of the mouse, to allow more control of small

cursor movement. Several different ways of implementing ballistics and other control adjustments in a force feedback device are described in co-pending patent application serial no. 08/924,462, filed 8/23/97, now U.S. Patent No. 6,252,579, and these adjustments can be used in mouse system 10 if desired.

Please replace the paragraph starting on page 11, line 30, with the following paragraph:

The mouse interface system 10 is useful for both position control ("isotonic") tasks and rate control ("isometric") tasks. For example, as a traditional mouse, the position of mouse 12 in its local frame 30 workspace can be directly mapped to a position of a cursor in host frame 28 on display screen 20 in a position control paradigm. Alternatively, the displacement of mouse 12 in a particular direction against an opposing output force can command rate control tasks in an isometric mode. An implementation that provides both isotonic and isometric functionality for a force feedback controller and which is very suitable for the interface device of the present invention is described in patent application serial no. 08/756,745, now U.S. Patent No. 5,825,308, incorporated by reference herein.

Please replace the paragraph starting on page 13, line 13, with the following paragraph:

A hand weight switch can also be provided which inherently causes indexing when the user removes hand or finger weight from mouse 12. In one embodiment, the functionality of a safety switch and the indexing mode are integrated into one input device, since it is typically desirable to deactivate any output forces to the mouse 12 when indexing is being performed for safety reasons or ergonomic reasons, e.g. forces intuitively should not be output when indexing occurs. Thus, a hand weight safety switch can be used as both a safety switch and an indexing switch. This type of indexing and hand weight safety switch are described in greater detail in parent patent applications serial no. 08/756,745, now U.S. Patent No. 5,825,308, and serial no. 08/881,691, now U.S. Patent No. 6,100,874.

Please replace the paragraph starting on page 13, line 21, with the following paragraph:

A different way to allow indexing is to provide a combined position control and rate control device which allows different forms of control of the cursor depending on the position of

the mouse in its workspace. If the mouse is positioned in an interior area of its workspace, the cursor is updated on the screen in a standard position control fashion. However, if the mouse is moved to an edge region near the limits to the workspace, a rate control paradigm is adopted. Preferably, a force is output on the mouse at the edge region border to resist motion toward the workspace limit, and the cursor is moved on the screen in a direction and rate corresponding to the mouse direction and distance of penetration against the force. The user can thus control the cursor to the edge of the screen based on mouse penetration into the rate control edge region ("pressure indexing"). This embodiment is described in greater detail in co-pending patent application 08/924,462, by Rosenberg et al., filed 8/23/97, now U.S. Patent No. 6,252,579 ~~(Atty Docket No. IMM1P032)~~, which is hereby incorporated by reference herein.

Please replace the paragraph starting on page 13, line 33, with the following paragraph:

Other features of the present invention are also provided using force feedback functionality. For example, thumb button 15a can toggle a force functionality mode in which designated graphical objects or regions displayed on screen 20 have other functions enabled by force feedback. A graphical object, such as a window or icon in a GUI, can act differently for selection of functions of the host computer or program, and/or for the forces associated with the object/region, depending on whether the force functionality mode is active. For example, when the mode is not active, the cursor can be moved normally through the border or edge of a window, with no force sensations associated with the movement over the window. However, when the force mode is active (such as by pressing or holding button 15a), a spring force will be output on mouse 12 opposing the movement of the cursor through the window border. This force is used as for "pressure scrolling" or as a "scroll surface", where the amount of penetration of the mouse against the spring force controls the speed of scrolling of a document displayed in that window. Alternatively, when the button 15a is held down by the user, an "isometric" or "pressure" mode can be entered at the current location of the cursor, where the mouse functions as an isometric controller. Such embodiments are described in patent application 08/756,745, now U.S. Patent No. 5,825,308. In a "pressure clicking" or "click surface" embodiment, if the cursor is moved against the border of an icon and the force functionality mode is active, a force will be output resisting motion of the cursor into the icon; when the mouse moves against the

force to a threshold distance, the icon is selected as if the cursor had clicked or double-clicked on the icon. Such an embodiment is described in co-pending patent application 08/879,296, entitled "Graphical Click Surfaces for Force Feedback Applications", by Rosenberg et al., filed 6/18/97, now U.S. Patent No. 6,078,308, incorporated by reference herein. In other embodiments, other input devices besides or in addition to button 15a can control the force functionality mode. Or, different input devices can control different modes; for example, one button can activate the pressure scrolling mode, while a different button can activate pressure clicking mode.

Please replace the paragraph starting on page 17, line 3, with the following paragraph:

The bearings used on linkage 40 can be of a wide variety of types. For example, a ball bearing assembly that includes rows of individual balls that ride in V-shaped grooves (bearing races) can be used. Alternatively, a snap bearing can be used, in which a cylindrical boss in one member mates with a cylindrical cavity included in a different member. A different type of bearing includes a V -shaped notch which mates with a V -shaped edge, where the angle between the sides of the notch is greater than the angle between the sides of edge by an amount greater than or equal to the desired range of angular motion provided by the bearing. These types of bearings are described in greater detail in parent patent application 08/881,691, now U.S. Patent No. 6,100,874.

Please replace the paragraph starting on page 18, line 1, with the following paragraph:

In alternate embodiments, capstan drive mechanisms (not shown) can be provided to transmit forces and motion between electromechanical transducers and the mouse 12. One example of the user of capstan drives is shown in parent application serial no. 08/756,745, now U.S. Patent No. 5,825,308. In alternate embodiments, mouse 12 can also be moved in an additional spatial degree of freedom using a rotatable carriage coupled between ground member 42 and base member 44. Such an embodiment is described in greater detail with reference to co-pending patent application serial no. 08/736,161, now U.S. Patent No. 5,828,197, incorporated by reference herein in its entirety.

Please replace the paragraph starting on page 18, line 19, with the following paragraph:

Sensors 62 are, in the described embodiment, grounded optical encoders that sense the intermittent blockage of an emitted beam. A grounded emitter/detector portion 71 includes an emitter that emits a beam which is detected by a grounded detector. A moving encoder disk portion or "arc" 74 is provided at the end of members 44 and 48 which each block the beam for the respective sensor in predetermined spatial increments and allows a processor to determine the position of the arc 74 and thus the members 44 and 48 by counting the spatial increments. Also, a velocity of members 44 and 48 based on the speed of passing encoder marks can also be determined. In one embodiment, dedicated electronics such as a "haptic accelerator" may determine velocity and/or acceleration, as disclosed in co-pending patent application 08/804,535, filed 2/21/97, now U.S. Patent No. 5,999,168, and hereby incorporated by reference herein. The operation of sensors 62 are described in greater detail with reference to Figures 4a-4c.

I9

Please replace the paragraph starting on page 19, line 17, with the following paragraph:

In an alternate embodiment, the mechanism 14 can be used for a 3-D interface device that allows a user to move a user object 12 in three dimensions rather than the 2-D planar workspace disclosed. For example, in one embodiment, the entire mechanism 14 can be made to rotate about a grounded axis, such as axis H extending through the actuators 64. For example, members (not shown) rigidly coupled to the actuators 64 or to grounded member 42 can extend in both directions along axis H and be rotary coupled to a grounded surface at points H1 and H2. This provides a third (rotary) degree of freedom about axis H to the mouse device 11 and to the user object 12. A motor can be grounded to the surface near point H1 or H2 and can drive the mechanism 14 about axis H, and a sensor, such as a rotary encoder, can sense motion in this third degree of freedom. One reason for providing axis H through the magnet assemblies is to reduce the inertia and weight contributed to motion about axis H by the magnet assemblies. Axis H can be provided in other positions in other embodiments. In such an embodiment, the user object 12 can be a stylus, grip, or other user object. A third linear degree of freedom to mechanism 14 can be provided in alternate embodiments. One embodiment of a planar linkage providing three degrees of freedom is disclosed in co-pending patent application serial no. 08/736,161 filed 10/25/96, now U.S. Patent No. 5,828,197, and hereby incorporated by reference herein.

I10

S2

Please replace the paragraph starting on page 21, line 27, with the following paragraph:

FIGURE 4a is a top plan view of the mechanical portion 24 of the interface device 11 showing the arrangement of sensors and actuators in the device. The present invention preferably uses voice coil actuators, some embodiments of which are described in detail in patent application serial no. 08/560,091, now U.S. Patent No. 5,805,140, and 08/881,691, now U.S. Patent No. 6,100,874, incorporated by reference herein.

I.11

Please replace the paragraph starting on page 23, line 28, with the following paragraph:

In the described embodiment, magnet assemblies 88a and 88b are preferably positioned adjacent to each other to provide a low profile. This allows housing 21 to have a low profile as well, and permits the mouse interface device 11 to be placed conveniently in locations on a desktop near a host computer. In addition, the low profile embodiment allows easier and thus cheaper assembly of the interface device 11. In an alternate embodiment, such as disclosed in parent application serial no. 08/881,691, now U.S. Patent No. 6,100,874, the grounded magnet assemblies can be stacked, one on top of the other. For example, a plate can be provided between the actuators and a portion of the flux path between the two magnetic assemblies can be shared by both actuators.

I.12

Please replace the paragraph starting on page 25, line 18, with the following paragraph:

In other embodiments, additional coils can also be provided for actuators 64 to provide different magnitudes of forces. For example, coil 82a can include multiple separate "sub-coils" of wire. A set of terminals can be included for each different sub-coil. Each sub-coil can include a different number of loops on portion 80 and therefore will generate a different magnetic field and thus a different magnitude of force when a constant current I is flowed through the sub-coil. This scheme is also applicable to a digital system using on and off switches. This embodiment is described in greater detail in co-pending application 08/560,091, now U.S. Patent No. 5,805,140.

I.13

Please replace the paragraph starting on page 25, line 25, with the following paragraph:

In other embodiments, linear actuators can be used to provide forces in provided degrees of freedom. Some examples of linear electromagnetic actuators are described in patent

I.14

application serial no. 08/560,091, now U.S. Patent No. 5,805,140. Also, other types of actuators may be used in place of or in addition to actuators 64 of the interface device. For example, the linkage can be driven by a direct drive DC motor or a geared/belt DC motor to provide mechanical advantage.

Please replace the paragraph starting on page 26, line 22, with the following paragraph:

Alternate embodiments can include sensors 62a and/or 62b (and/or actuators 64) in different positions. For example, the emitter and detector can be on opposite sides of arc 74. In yet other embodiments, other types of sensors can be used. For example, a single sensor can be used to detect motion in both degrees of freedom. Alternatively a rotary sensor including a friction wheel can be provided; or, a planar sensor or "touch pad" having rectangular sensing area and a pointer can be used to sense the x and y position and/or pressure in the z-direction. A light pipe can also be used to direct the beam emitted from the emitter to the detector for sensor 62a and/or 62b. These alternate embodiments are described in detail in parent patent application serial no. 08/881,691, now U.S. Patent No. 6,100,874, incorporated by reference herein.

Please replace the paragraph starting on page 28, line 18, with the following paragraph:

FIGURE 6 is a block diagram illustrating the electronic portion of interface 14 and host computer 18 suitable for use with the present invention. Mouse interface system 10 includes a host computer 18, electronic interface 26, mechanical portion 24, and mouse or other user object 12. Electronic interface 26, mechanical portion 24, and mouse 12 can also collectively be considered the "force feedback interface device" 11 that is coupled to the host computer. A similar system is described in detail in co-pending patent application serial no. 08/566,282, now U.S. Patent No. 5,734,373, which is hereby incorporated by reference herein in its entirety.

Please replace the paragraph starting on page 30, line 18, with the following paragraph:

For example, in one host-controlled embodiment that utilizes microprocessor 130, host computer 18 can provide low-level force commands over bus 120, which microprocessor 130 directly transmits to the actuators. In a different local control embodiment, host computer system 18 provides high level supervisory commands to microprocessor 130 over bus 120, and

microprocessor 130 manages low level force control loops to sensors and actuators in accordance with the high level commands and independently of the host computer 18. In the local control embodiment, the microprocessor 130 can process inputted sensor signals to determine appropriate output actuator signals by following the instructions of a "force process" that may be stored in local memory and includes calculation instructions, formulas, force magnitudes, or other data. The force process can command distinct force sensations, such as vibrations, textures, jolts, or even simulated interactions between displayed objects. An "enclosure" host command can also be provided, which causes the microprocessor to define a box-like enclosure in a graphical environment, where the enclosure has sides characterized by wall and texture forces, as described in co-pending application 08/881,691, now U.S. Patent No. 6,100,874. The host can send the local processor a spatial layout of objects in the graphical environment so that the microprocessor has a mapping of locations of graphical objects like enclosures and can determine interactions with the cursor locally. Force feedback used in graphical environments is described in greater detail in co-pending patent application serial nos. 08/571,606, now U.S. Patent No. 6,219,032, 08/756,745, now U.S. Patent No. 5,825,308, and 08/924,462, now U.S. Patent No. 6,252,579, all of which are incorporated by reference herein.

Please replace the paragraph starting on page 31, line 1, with the following paragraph:

Sensor signals used by microprocessor 130 are also reported to host computer system 18, which updates a host application program and outputs force control signals as appropriate. For example, if the user moves mouse 12, the computer system 18 receives position and/or other signals indicating this movement and can move a displayed cursor in response. These embodiments are described in greater detail in co-pending applications serial nos. 08/534,791, now U.S. Patent No. 5,739,811, and 08/566,282, now U.S. Patent No. 5,734,373. In an alternate embodiment, no local microprocessor 130 is included in interface system 10, and host computer 18 directly controls and processes all signals to and from the interface 26 and mechanical portion 24.

Please replace the paragraph starting on page 33, line 20, with the following paragraph:

Mechanism 40 is preferably the five-member linkage 40 described above, but can also be one of several types of mechanisms. For example, mechanisms disclosed in co-pending patent applications serial nos. 08/374,288, now U.S. Patent No. 5,731,804, 08/400,233, now U.S. Patent No. 5,767,839, 08/489,068, now U.S. Patent No. 5,721,566, 08/560,091, now U.S. Patent No. 5,805,140, 08/623,660, now U.S. Patent No. 5,619,898, 08/664,086, now U.S. Patent No. 6,028,593, 08/709,012, now U.S. Patent No. 6,024,576, and 08/736,161, now U.S. Patent No. 5,828,197, all incorporated by reference herein, can be included. Mouse 12 can alternatively be a puck, joystick, or other device or article coupled to linkage 40, as described above.

I.19